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Indian Standard

PLASTICS USED IN INSTRUMENT INDUSTRY

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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April 1974

Indian Standard
PLASTICS USED IN INSTRUMENT INDUSTRY

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(*Continued on page* 2)

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(*Continued from page* 1)

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Indian Standard

PLASTICS USED IN INSTRUMENT INDUSTRY

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 October 1973, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 This standard provides useful data on plastic materials commonly used in the fabrication of instruments or instrument parts, and facilitates selection of the proper plastic for any particular purpose. It further provides information relating to the types and forms in which these plastics are normally available, and suggests methods of selection for use in instrument industry.

1. SCOPE

1.1 This standard covers the physical characteristics and end uses of commonly used types of plastic materials. In order to facilitate comparison and proper selection of plastic material for instruments, the commonly used trade names have also been indicated.

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions given in IS : 1399-1959* and IS : 2828-1964†, and the following shall apply.

2.1 Compressive Strength — Physical property of the material to stand up to compressive force. It is the highest stress reached before the material breaks under compression.

2.2 Cold Flow — Dimensional change due to applications of sustained loads in excess of elastic limit.

2.3 Heat Sealing — The joining together of films of thermoplastic materials by the application of heat and pressure (except high frequency heat).

3. TYPES

3.1 Plastics are broadly classified in two categories as follows:

a) Thermoplastic materials, and
b) Thermosetting materials.

4. FORMS

4.1 Plastics are normally available in form of rod, tube, sheet, block, film, foil, granule, fine powder, bead, foam, fibre, fabric, emulsion, organic solution, resin and paste.

5. COLOURS

5.1 Plastics are available in transparent, translucent or opaque grades. The colour range extends to pearls, mottles and metallics.

5.2 Besides, plastics may be dyed in practically all colours like black, brown, maroon, green, blue and other natural colours in darker shades.

6. POSSIBLE APPLICATIONS

6.1 In instruments industry, plastics find their use in the fabrication of dials, cells, batteries, knobs, panels, optical components, protractors, set squares, scales, French curves, railway curves, tracing materials, instrument cases, photographic films, surgical instruments, laminates, switches, bearings, gears, cams, washers, gaskets, bellows, diaphragms, piston rings, pressure tapes, valve holders, handles, and shock absorbing systems, etc. Plastics are also used for electrical fittings, packaging and safety glass interlayers, etc.

7. GENERAL REQUIREMENTS

7.1 Stones and Crystallization Bodies — Plastics intended for use in instruments and instrument parts shall be totally free from the fragments of undispersed raw material, streaks, particles of foreign matter, crystallized deposits and deposits of any of the constituents.

7.2 Durability — The material shall be durable and free from surface acidity or alkalinity. The polished surfaces shall be capable of withstanding atmospheric attack.

7.3 There shall be no defects like blisters, porosity, blemishes, pinholes, pits, bloom and chalking, and the edges shall be free from cuts.

7.4 Plastics used in instruments and instrument parts shall not appreciably crack, wrinkle and show surface impairment or sign of warpage during its use.

7.5 Plastics used for instruments shall be able to withstand constant handling and shall have good insulation property, dimensional stability and resistance to heat, hot water, solvents and chemicals.

---

*Glossary of terms used in optical technology.

†Glossary of terms used in the plastics industry.

7.6 Plastic materials used for fabrication of an instrument shall be smooth and preferably non-inflammable.

7.7 The material shall have capability of withstanding repeated deformation when used for fabrication of flexible parts which are subjected to repeated mechanical stresses.

8. SPECIAL REQUIREMENTS

8.1 When used as an optical element, plastic materials shall, in addition to satisfying the requirements laid down in **7**, conform to the requirements of optical glass as specified in IS : 1400-1960*.

9. METHODS OF SELECTION

9.1 The selection of a suitable plastic material for a particular instrument shall depend mainly on its physical and chemical characteristics.

9.1.1 In case of electrical and electronic instruments, the dielectric strength and other electrical properties of the intended plastic material shall be taken into consideration.

9.1.2 In choosing a suitable material for instrument designed to function in extreme field service conditions, the water absorption of the material, its dimensional stability, thermal expansion and resistance to weathering conditions shall be the main basis of selection. In addition to these, the different physical properties shall also be taken into consideration.

9.1.3 In the selection of a plastic material for any other type of instrument, the consideration of the colour of the material, its specific gravity and other physical characteristics shall depend upon the nature and type of work to be taken by the instrument.

9.2 After selecting a suitable material for the required purpose, the proper form available shall be chosen for the particular work. In case the intended form is not available, choice for the next suitable material shall be made, if possible.

9.3 The forms available, physical characteristics and possible applications of different thermoplastic and thermosetting materials are given in Appendix A and Appendix B respectively. The possible applications given in Appendices A and B may be taken as a guide in the selection of a material.

9.4 In selecting suitable plastic material to replace any metal part in an instrument, the design for plastics must be taken into account, for what is considered good design practice for metals will not necessarily be good practice for moulded plastics.

10. PLASTICS USED IN INSTRUMENT INDUSTRY

10.1 The following thermoplastic materials have been covered in Appendix A:

	Material	*Abbreviation*
1)	Acetal	POM
2)	Acrylonitrile butadiene styrene	ABS
3)	Cellulose acetate	CA
4)	Cellulose acetate butyrate	CAB
5)	Cellulose nitrate (celluloid)	CN
6)	Cellulose propionate	—
7)	Cellulose triacetate	CTA
8)	Chlorinated polyether	—
9)	Ethyl cellulose	EC
10)	Fluorocarbons	
	i) Polytetrafluoroethylene	PTFE or TFE
	ii) Polytrifluorochloroethylene	PTFCE or PCTFE
	iii) Fluoroethylene propylene or fluorinated ethylene propylene	FEP
	iv) Fluorohalocarbon	—
11)	Polyamide (nylon)	PA
12)	Polycarbonates	PC
13)	Polyethylene (high density above 0·940)	HDPE
14)	Polyethylene (low density up to 0·925 and medium density from 0·925 to 0·940)	LDPE
15)	Polymethyl methacrylate (acrylic)	PMM or PMMA
16)	Polypropylene	PP
17)	Polystyrene	PS
18)	Polyurethane	PU
19)	Polyvinyl butyral	PVB
20)	Polyvinyl chloride (unplasticized, rigid and flexible)	PVC
21)	Polyvinylidene chloride (Saran)	PVDC

10.2 The following thermosetting materials have been covered in Appendix B:

	Material	*Abbreviation*
1)	Alkyd	AK
2)	Epoxy resins (epoxide)	EP
3)	Melamine formaldehyde (melamine)	MF
4)	Phenolic (phenol formaldehyde)	PF
5)	Polyester	PR
6)	Urea formaldehyde (urea)	UF

11. TESTS

11.1 Plastics shall be tested for their different physical characteristics by the methods specified in the relevant Indian Standards.

11.2 Plastic materials used as optical elements shall be tested for optical properties by the methods specified in IS : 1400-1960*.

---

*Specification for optical glass.

12. PACKING AND PACKAGING

12.1 Plastic materials shall be wrapped in packing paper and then the packages shall be secured by adhesive tapes.

12.2 Each package shall be marked clearly with the type of material, form and size in which supplied.

12.3 Such packages shall then be packed in well-closed moisture proof containers in accordance with the normal commercial practice.

12.4 Information regarding the type, form, size and quantity of the material together with the name of the manufacturer and place shall be marked on the box (container).

12.5 Wherever required, the packaging shall be done in accordance with the agreement between the purchaser and the supplier.

13. UNITS

13.1 Various units used in Appendices A and B are as follows:

a) Density	g/cm^3
b) Water absorption	percent in 24 hours
c) Tensile strength	MPa or MN/m^2
d) Compressive strength	MPa or MN/m^2
e) Impact strength	J
f) Thermal expansion	cm/cm °C
g) Injection moulding/ moulding temperature	°C
h) Dielectric strength	$\frac{\text{V}}{\mu\text{m}}$

---

*Specification for optical glass.

APPENDIX A

(*Clauses* 9.3, 10.1 *and* 13.1)

PLASTICS USED IN INSTRUMENTS INDUSTRY, THERMOPLASTIC MATERIALS

SL No. (1)	MATERIALS (2)	FORMS AVAILABLE (3)	PHYSICAL CHARACTERISTICS (4)	POSSIBLE APPLICATIONS (5)	COMMON TRADE NAMES (6)
1	Acetal	Rod Tube Sheet Granules Resin	Translucent and opaque colours, natural material is cream or white Specific gravity 1·41-1·425 Water absorption 0·12-0·2 Tensile strength 56·2-70·3 Compressive strength 112·5-126·5 Impact strength 1·5-3·0 Thermal expansion $8\text{-}8{\cdot}2 \times 10^{-5}$ Injection moulding temperature 170-225 Dielectric strength 15·80-19·70 Refractive index 1·48 Inflammability Slow burning One of strongest and stiffest plastic, high gloss, noteworthy resistance to organic solvents, poor resistance to acids and alkalis, good abrasion resistance, low coefficient of friction	Bearings Instrument casings Gears Cams Hinges Handles	Celcon (copolymer) Delrin (homopolymer) Hostaform (copolymer)
2	Acrylonitrile butadiene styrene	Granules Sheet Pipe Rod Resin	Translucent to opaque colours Specific gravity 1·02-1·1 Water absorption 0·2-0·3 Tensile strength 21·1-64·7 Compressive strength 17·5-77·3 Impact strength 9·8-117·7 Thermal expansion $7{\cdot}3\text{-}10{\cdot}4 \times 10^{-5}$ Injection moulding temperature 180-250 Dielectric strength 13·80-19·70 Inflammability Slow burning Rigid and hard material having a fair to medium surface gloss. It is cream translucent in natural form	Instrument panels Vacuum cleaners Storage cases	Abson Abstrene Afcolene Blendex (resin) Cycolae Cycolon Editer Kralastic Lorkaril Lustran Novodur Royalite (sheet) Sicoflex Tronal (sheet) Urtal
3	Cellulose acetate	Rod Tube Sheet Block Film Granules Fabric Solution	Transparent and all colours in translucent and opaques, including mottles, pearls and metallics Specific gravity 1·25-1·35 Water absorption 0·25-4·0 Tensile strength 10·5-56·2 Compressive strength 126·5-175·8 Impact strength 0·7-6·5 Thermal expansion $8\text{-}15 \times 10^{-5}$ Injection moulding temperature 155-220 Dielectric strength 5·9-25·6 Refractive index 1·5 Inflammability Slow burning Ease of moulding, ease of fabrication, superior clearness, durable, flexible in thin sections	Spectacles frames Film spools Electrical components Recording tapes Photographic films Knobs Packaging Safety glass interlayers Eye shields Cine films Drafting instruments	Acelon Acetable Bexoid Celastoid Cellidor A, S, U Clarifoil Dexel Erinoid acetate Kodapak-1 Lustrac Monoflex Nixon CA Rhodoid Sicatel Tenite 1 Tenite acetate

4	Cellulose acetate butyrate or cellulose acetobutyrate	Tube Sheet Film Granules Fine powder	Transparent and all colours in translucent and opaques, including mottles, pearls and metallics Specific gravity 1·15-1·22 Water absorption 0·9-2·2 Tensile strength 17·5-49·2 Compressive strength 35·1-140·6 Thermal expansion 11-17 × 10^{-5} Injection moulding temperature 160-220 Dielectric strength 9·85-15·80 Refractive index 1·46-1·49 Inflammability Slow burning Resistance to heat and weathering conditions, high gloss, good dimensional stability, flexible in thin sections	Knobs Tool handles Packaging Photographic film spools Signal lenses Drafting instruments	—
5	Cellulose nitrate (celluloid)	Sheet Film Solution	Transparent, translucent and opaque colours, including pearls, mottles and metallics Specific gravity 1·35-1·7 Water absorption 0·5-2·0 Tensile strength 38·7-66·8 Compressive strength 154·7-246·0 Impact strength 8·1-10·8 Thermal expansion 6-16 × 10^{-5} Dielectric strength 9·85-13·80 Refractive index 1·49-1·51 Inflammability Highly inflammable Ease of machining, ease of fabrication, flexible in thinner sections	Spectacle frames Safety glass interlayers French curves Drawing instruments	Aceloid Celluloid Cinelin Kodaloid Lusteroid Nilron Nixon Cn Pyralin Xylonite
6	Cellulose propionate	Granules Sheet Film	Transparent, translucent and opaque colours Specific gravity 1·17-1·24 Water absorption 1·2-2·0 Tensile strength 18·3-47·8 Compressive strength 16·9-154·7 Impact strength 1·4-13·7 Thermal expansion 10-15 × 10^{-5} Injection moulding temperature 150-260 Dielectric strength 31·5-59·1 Refractive index 1·46-1·49 Inflammability Slow burning Tough dense material with high gloss. Flexibility varies with plasticizer content. Excellent transparency, good grease resistance and freedom from discolouration, embrittlement upon ageing	Optical frames Safety goggles	Celadex Forticel Tenite propionate
7	Cellulose triacetate	Film	Transparent colours Specific gravity 1·26-1·34 Water absorption 1·3-3·1 Tensile strength 56·2-77·3 Compressive strength 98·4-140·6 Impact strength 1·4-6·8 Thermal expansion 10-16 × 10^{-5} Dielectric strength 9·85-13·80 Inflammability Slow burning Improved dimensional stability, good heat resistance, higher softening temperature and lower dielectric loss	Packaging Sound recording Photographic	Kodapak IV

(*Continued*)

APPENDIX A — *Contd*

(*Clauses* 9.3, 10.1 *and* 13.1)

PLASTICS USED IN INSTRUMENTS INDUSTRY, THERMOPLASTIC MATERIALS

<table>
<tr><th>Sl No.
(1)</th><th>Materials
(2)</th><th>Forms Available
(3)</th><th>Physical Characteristics
(4)</th><th>Possible Applications
(5)</th><th>Common Trade Names
(6)</th></tr>
<tr><td>8</td><td>Chlorinated polyether</td><td>Rod
Tube
Sheet
Granules
Fine powder</td><td>A tough, straw-tinted creamy translucent material, in its natural form, natural tan and few restricted colours
<table>
<tr><td>Specific gravity</td><td>1·4</td></tr>
<tr><td>Water absorption</td><td>0-0·1</td></tr>
<tr><td>Tensile strength</td><td>42·2</td></tr>
<tr><td>Compressive strength</td><td>—</td></tr>
<tr><td>Impact strength</td><td>3·9</td></tr>
<tr><td>Thermal expansion</td><td>6·6-8·2 × 10^{-5}</td></tr>
<tr><td>Injection moulding temperature</td><td>200-240</td></tr>
<tr><td>Dielectric strength</td><td>15·80</td></tr>
<tr><td>Refractive index</td><td>—</td></tr>
<tr><td>Inflammability</td><td>Self-extinguishing</td></tr>
</table>
An unusual combination of mechanical, electrical and chemical-resistance properties that makes it possible to fabricate parts which remain extremely stable under severe service conditions, semi-flexible in thin section</td><td>Precision machine gears
Pins
Bushings
Linings
Coatings</td><td>Penton
Solpolen</td></tr>
<tr><td>9</td><td>Ethyl cellulose</td><td>Rod
Tube
Sheet
Film
Powder</td><td>Transparent, translucent and opaque colours
<table>
<tr><td>Specific gravity</td><td>1·1-1·17</td></tr>
<tr><td>Water absorption</td><td>0·7-1·9</td></tr>
<tr><td>Tensile strength</td><td>21·1-56·2</td></tr>
<tr><td>Compressive strength</td><td>70·3-105·5</td></tr>
<tr><td>Thermal expansion</td><td>10-15 × 10^{-5}</td></tr>
<tr><td>Injection moulding temperature</td><td>150-220</td></tr>
<tr><td>Dielectric strength</td><td>8·70-15·80</td></tr>
<tr><td>Refractive index</td><td>1·47</td></tr>
<tr><td>Inflammability</td><td>Slow burning</td></tr>
</table>
Varied degrees of flexibility, excellent dimensional stability, resistance to heat and weather, resistance to alkalis, high surface gloss</td><td>Tool handles
Coatings
Lacquers
Packaging
Containers</td><td>Cellophane*
Diophane*
Ethocel
Ethulon
Hercocel E
Inceloid E
Nixon EC
Sicophane*
Troiit

*Trade names for films</td></tr>
<tr><td>10</td><td>Fluorocarbons</td><td>Granules
Powder
Rod
Sheet
Tape
Film
Solution</td><td>Generally available in natural colour only but can be pigmented if required
<table>
<tr><th></th><th><i>PTFE</i></th><th><i>PTFCE</i></th><th><i>FEP</i></th><th><i>Fluorohalocarbon</i></th></tr>
<tr><td>Specific gravity</td><td>2·14-2·2</td><td>2·1</td><td>2·14-2·17</td><td>2·1-2·16</td></tr>
<tr><td>Water absorption</td><td>Nil</td><td>Nil</td><td>0·01</td><td>Nil</td></tr>
<tr><td>Tensile strength</td><td>10·5-28·1</td><td>32·3-40·1</td><td>19·0-21·8</td><td>30·2-35·1</td></tr>
<tr><td>Compressive strength</td><td>10·5-12·6</td><td>225·0-562·5</td><td>—</td><td>31·6-52·7</td></tr>
<tr><td>Impact strength</td><td>4·0-6·0</td><td>1·6-4·9</td><td>No break</td><td>6·4-36·3</td></tr>
<tr><td>Thermal expansion</td><td>5·5-10 × 10^{-5}</td><td>4·5-7 × 10^{-5}</td><td>8·3-10·5 × 10^{-5}</td><td>4·77-7·2 × 10^{-5}</td></tr>
<tr><td>Injection moulding temperature</td><td>360-400</td><td>225-300</td><td>315-400</td><td>—</td></tr>
<tr><td>Refractive index</td><td>1·35</td><td>1·425</td><td>1·338</td><td>—</td></tr>
<tr><td>Dielectric strength</td><td>15·80-19·70</td><td>20·90-23·60</td><td>19·70-23·60</td><td>18·5-19·30</td></tr>
<tr><td>Inflammability</td><td colspan="4">←—— Nonflammable ——→</td></tr>
</table>
Greater working temperature range than others, unsurpassed chemical resistance, self-lubricating nonsticking properties, very low friction, excellent electrical properties</td><td>Electrical insulation
Tapes and films
Bearings (self-lubricating)
Piston rings
Coil formers
Gaskets
Diaphragms
Nonstick coatings</td><td><i>PTFE</i>
Algoflon
Fluon
Halon
Sereflon
Teflon

<i>PTFCE</i>
Hostaflon — C
Kel — F

<i>FEP</i>
Teflon Fep

<i>Fluorohalocarbon</i>
Halon</td></tr>
</table>

<table>
<tr>
<td>11</td>
<td>Polyamide (nylon)</td>
<td>Rod
Tube
Film
Granules
Fine powder
Fibre
Solution</td>
<td>Natural and opaque (translucent in thin sections)
<table>
<tr><th></th><th><i>Type 6</i></th><th><i>Type 6·6</i></th><th><i>Type 6·10</i></th><th><i>Type 11</i></th><th><i>Type 12</i></th></tr>
<tr><td>Specific gravity</td><td>1·13</td><td>1·14</td><td>1·09</td><td>1·04-1·05</td><td>1·01-1·02</td></tr>
<tr><td>Water absorption</td><td>1·6-3</td><td>1·5</td><td>0·33-0·4</td><td>0·3-0·4</td><td>0·25</td></tr>
<tr><td>Tensile strength</td><td>70·3</td><td>70·3-83·0</td><td>49·9-59·8</td><td>59·8</td><td>49-56</td></tr>
<tr><td>Compressive strength</td><td>49·2-91·4</td><td>49·2-91·4</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>Impact strength</td><td>1·4-3·4</td><td>1·2-2·7</td><td>0·8-2·7</td><td>9·5</td><td>2·7-7·4</td></tr>
<tr><td>Thermal expansion</td><td>5×10^{-5}</td><td>$5{\cdot}5\times10^{-5}$</td><td>$5{\cdot}5\times10^{-5}$</td><td>6×10^{-5}</td><td>$10{\cdot}4\times10^{-5}$</td></tr>
<tr><td>Injection moulding temperature</td><td>225-280</td><td>275-300</td><td>235-255</td><td>220-250</td><td>180-270</td></tr>
<tr><td>Dielectric strength</td><td>13·0-15·80</td><td>13·80-19·70</td><td>13·80-15·80</td><td>8·70</td><td>17·80</td></tr>
<tr><td>Refractive index</td><td>—</td><td>1·53</td><td>—</td><td>1·52</td><td>—</td></tr>
<tr><td>Inflammability</td><td colspan="5">←—— Self-extinguishing ——→</td></tr>
</table>
Types 6, 6.6, 6.10, and 11 — High mechanical strength, resistance to abrasion and heat, self-lubricating, flexible in thin sections
Type 12 — Low water absorption and low shrinkage</td>
<td>Spectacle frames
Bearings (self-lubricating)
Knobs
Shock absorbing system
Silent running gears
Coil formers
Washers
Chain links
Gears
Coatings
Cams
Bearings
Electrical insulation</td>
<td><i>Type 6</i>
Akulon
Durethan
Grilon
Maranyl
Sniamide
Ultramid B
<i>Type 6.6</i>
Maranyl
Nylon Ap
Ultramid A
Zytel
<i>Type 6.10</i>
Maranyl
Nylon Cp
Technyl
Ultramid
Zytel
<i>Type 11</i>
Rilsan
<i>Type 12</i>
Rilsan-A
Vestamid</td>
</tr>
<tr>
<td>12</td>
<td>Polycarbonates</td>
<td>Rod
Tube
Sheet
Film</td>
<td>Transparent and a limited range of translucent and opaque colours, clear or slight tint in natural form
<table>
<tr><td>Specific gravity</td><td>1·2-1·22</td></tr>
<tr><td>Water absorption</td><td>0·2-0·3</td></tr>
<tr><td>Tensile strength</td><td>56·2-73·8</td></tr>
<tr><td>Compressive strength</td><td>72·4-75·9</td></tr>
<tr><td>Impact strength</td><td>2·7-4·0</td></tr>
<tr><td>Thermal expansion</td><td>$6\text{-}7\times10^{-5}$</td></tr>
<tr><td>Injection moulding temperature</td><td>275-315</td></tr>
<tr><td>Dielectric strength</td><td>15·80-17·30</td></tr>
<tr><td>Refractive index</td><td>1·586</td></tr>
<tr><td>Inflammability</td><td>Self-extinguishing</td></tr>
</table>
High gloss, resistance to weathering</td>
<td>Electronic components
Lenses
Insulation
Photography</td>
<td>Lexan
Malerolen
Marlon
Polycarbafil</td>
</tr>
<tr>
<td>13</td>
<td>Polyethylene (high density above 0·940)</td>
<td>Rod
Tube
Sheet
Block
Film
Granules
Fine powder
Foam
Fabric</td>
<td>Natural, semitranslucent and opaque colour
<table>
<tr><td>Specific gravity</td><td>0·941-0·965</td></tr>
<tr><td>Water absorption</td><td>0·01</td></tr>
<tr><td>Tensile strength</td><td>21·1-35·1</td></tr>
<tr><td>Compressive strength</td><td>19·0-25·3</td></tr>
<tr><td>Impact strength</td><td>1·4-4·3</td></tr>
<tr><td>Thermal expansion</td><td>$11\text{-}13\times10^{-5}$</td></tr>
<tr><td>Injection moulding temperature</td><td>200-275</td></tr>
<tr><td>Dielectric strength</td><td>18·90-21·70</td></tr>
<tr><td>Refractive index</td><td>1·54</td></tr>
<tr><td>Inflammability</td><td>Slow burning</td></tr>
</table>
Crisp, harder surface, higher softening points, greater resistance to stress cracking and permeation, lower absorption of certain organic solvents</td>
<td>Cable insulation
Handles
Machinery covers
Crates and boxes
Coatings
Adhesive tapes</td>
<td>Ameripol
Bakelite polyethylene
Carlona polyethylene
Catalin polyethylene
Dow polyethylene
Elrex polyethylene
Fortiflex
Grex
Hifax
Hostalen
Lupolen
Marlex
Nastene
Osnalen-II
Regidex
Rholene
Shell polyethylene
Super dylan
Tenite polyethylene
Vestolen-A</td>
</tr>
</table>

(*Continued*)

APPENDIX A — *Contd*

(*Clauses* 9.3, 10.1 *and* 13.1)

PLASTICS USED IN INSTRUMENTS INDUSTRY, THERMOPLASTIC MATERIALS

Sl No. (1)	Materials (2)	Forms Available (3)	Physical Characteristics (4)	Possible Applications (5)	Common Trade Names (6)
14	Polyethylene (low density up to 0·925 and medium density from 0·925 to 0·940)	Rod Tube Sheet Block Film Granules Fine powder Foam Fibre Fabric Solution	Natural, semitranslucent and opaque colours Specific gravity 0·915-0·940 Water absorption 0·01 Tensile strength 7·0-21·1 Impact strength 2·7-27·2 Thermal expansion $10\text{-}20 \times 10^{-5}$ Injection moulding temperature 200-275 Dielectric strength 19·70-39·40 Refractive index 1·51-1·52 Inflammability Slow burning Flexible, soft easily marked surface, excellent resistance to ageing, weathering, hot water and chemicals, ease of moulding, unsurpassed electrical properties, good dimensional stability, nontoxic	Electrical components Chemical apparatus Handles Gaskets Coatings Adhesive tapes Electrical insulations	Alathon Alkathene Bakelite Dow (polyethylene) Dylan Elrex Epolen Fertene Fortiflex Lupolen Marlex Osnalen-I Petrothene Plastylene Riblene Stamylan Telcothene Tenite Trolen Vestolene-A
15	Polymethyl methacrylate (acrylic)	Rod Tube Sheet Film Granules Block Fine powder Polymer Bead Fibre Emulsion Organic solution Resin	Transparent and all colours in translucent and opaque Specific gravity 1·14-1·18 Water absorption 0·2-0·3 Tensile strength 31·5-80·8 Compressive strength 84·3-105·5 Impact strength 0·34-3·4 Thermal expansion $3\text{-}8 \times 10^{-5}$ Injection moulding temperature 170-280 Dielectric strength 15·80-19·70 Refractive index 1·47 Inflammability Slow burning High surface gloss, semibrittle in high impact grades, superior clearness, resistance to water and weathering conditions, dimensional stability, ease of machining, good heat and chemical resistance, exceptional optical properties	Instrument cases Wind screens French curves Fluorescent lighting diffusers Surgical instruments Scales Lenses Protractors and set squares Dial and panels Glazing Fibre optics	Acronal Acrylete Diakon Implex Kallodoc Lucite Oroglas Perspex Plexiglas Plexigum Vedril Zerlon
16	Polypropylene	Rod Tube Sheet Film Foil Granules Fine powder Fabric	Natural, semitranslucent and opaque colours Specific gravity 0·90-0·91 Water absorption 0·01-0·03 Tensile strength 28·1-36·6 Compressive strength 59·8-77·3 Impact strength 0·68-6·7 Thermal expansion $8{\cdot}5\text{-}11 \times 10^{-5}$ Injection moulding temperature 200-300 Dielectric strength 30·3-32·30 Refractive index 1·49 Inflammability Slow burning Lightest thermoplastic material, high melting point, excellent electrical properties, high surface gloss, superior stress-cracking resistance, higher stiffness and heat resistance, lower shrinkage and distortion, high elongation properties	Packaging Carrying cases Cable and wire covering Electronic components	Carlona-P Catalin polypropyle Elrex polypropyle Gering-PP Herculon Hostalen PP Luparen Moplen Oleform Osnalen-IV Poly-Pro Profax Propathene Shell-polypropyle

17	Polystyrene	Rod Tube Sheet Block Film Foil Granules Fine powder Beat Foam Fibre Emulsion Solution Resin	Transparent, translucent and opaque colours including pearls and metallics Specific gravity 1·04-1·07 Water absorption 0·03-0·05 Tensile strength 31·6-52·7 Compressive strength 84·4-112·5 Impact strength 0·27-0·53 Thermal expansion $6\text{-}10 \times 10^{-5}$ Injection moulding temperature 150-280 Dielectric strength 15·80-21·70 Refractive index 1·57-1·60 Inflammability Slow burning High surface gloss, resistance to heat, high electrical and dimensional properties	Electrical insulators Coil formers Seals Knobs Packaging containers Light fittings Instrument panels	Afcolene Bextrene Carinex Catalin Cosden Distrene Dylene Elrex Evenglo Fostalite Fostarene Grace Kardel Lorkalenes Lucentine Lustrex Polyflex Polystyrol Sicostirol Starex Styrafile Styroflex Styron Styroplasto Trolitul Trycite Vestyron Visolyte
18	Polyurethane	Sheet Film Granules Foam Fibre Resin	Generally natural colour in moulding grades, the natural state is an amber clear material Specific gravity 1·21-1·26 Water absorption 0·2-0·8 Tensile strength 35·1-59·8 Compressive strength 28·1-84·4 Impact strength No break Thermal expansion $10\text{-}15 \times 10^{-5}$ Injection moulding temperature 150-200 Dielectric strength 15·80-25·60 Refractive index 1·50-1·60 Inflammability Slow burning Dimensional stability, electrical properties; good resistance to abrasion, oil, petrol, oxygen and ozone	Bearings Gears Coil formers Electronic components Packaging Electrical insulations Handles Seals	Durcthane U Duthane Estane Texin
19	Polyvinyl butyral	Liquid regions of varying viscosity Moulding powder Flakes Lacquers	Colourless Specific gravity 1·05-1·50 Water absorption 1·0-3·0 Tensile strength 28·1-56·2 Compressive strength — Impact strength 1·1-1·6 Thermal expansion $8\text{-}22 \times 10^{-5}$ Injection moulding temperature 121-171 Dielectric strength 9·45-13·80 Refractive index 1·47-1·49 Inflammability Slow burning Excellent scuff resistance, low temperature flexibility, clarity and adhesiveness	Safety glass interlayers Electrical instrument housing Adhesives Coatings Metal primers	Butacite Butvar Saflex Vinylite

(*Continued*)

APPENDIX A — *Contd*

(*Clauses* 9.3, 10.1 *and* 13.1)

PLASTICS USED IN INSTRUMENTS INDUSTRY, THERMOPLASTIC MATERIALS

SL No. (1)	MATERIALS (2)	FORMS AVAILABLE (3)	PHYSICAL CHARACTERISTICS (4)	POSSIBLE APPLICATIONS (5)	COMMON TRADE NAMES (6)
20	Polyvinyl chloride (unplasticized, rigid and flexible)	Rod Tube Sheet Film Granules Powder Foam Fibre Emulsion Solution Resin Paste	Transparent and all colours in translucent and opaque including metallics Specific gravity 1·20-1·45 Water absorption 0·1-1·0 Tensile strength 10·5-70·3 Compressive strength 70·3-91·4 Impact strength 0·53-2·7 Thermal expansion 7-25 × 10^{-5} Injection moulding temperature 120-160 Dielectric strength 13·80-19·70 Refractive index 1·52-1·55 Inflammability Very slow burning to nonflammable Dimensional stability, resistance to weathering conditions, resistance to abrasion and chemical action, clearness, ease of moulding, odourless, and tasteless, rigidity and varying flexibility	French curves Protractors Set squares Printing plates Sealing rings Packaging fume ducts Electrical insulation Safety glass interlayers	Astradur Benvic Bonyl Breon — PVC Carina Corex Corvic Erinoid — PVC Garbel Geon — PVC Hostalit Lucolene Lucorex Lutofan Marvinol Mipolam Novan ten Opalon Plastovac — P Pliovic Ravinil Sicron Solvic Trovidur Vestolit Vestoran Villit Vinatex Vinoflex Vipla Viplast Vybac Vygen Vynco Vyram Welvic
21	Polyvinylidene chloride (Saran)	Emulsion Lacquers Tube Pipe Sheet Film Filament	White, odourless, tasteless and nontoxic Specific gravity 1·67 Water absorption 0·12 Tensile strength 28·1-49·2 Compressive strength 31·6-59·8 Impact strength 2·7-11·0 Thermal expansion 16-19 × 10^{-5} Dielectric strength 11·80-15·80 Refractive index 1·60-1·63 Inflammability Very difficult to ignite, self-extinguishing High impact strength, toughness and durability, excellent weather, chemical and electrical resistance	Coatings Packaging foils Containers Window screws	Geon Ixan Kurofan Saran

APPENDIX B

(*Clauses* 9.3, 10.2 *and* 13.1)

THERMOSETTING MATERIALS

SL No. (1)	MATERIAL (2)	FORMS AVAILABLE (3)	PHYSICAL CHARACTERISTICS (4)	POSSIBLE APPLICATIONS (5)	COMMON TRADE NAMES (6)
1	Alkyd	Moulding materials Resins Granules	Natural and certain basic opaque colours Specific gravity 1·8-2·5 Water absorption 0·05-0·25 Tensile strength 21·0-70·0 Compressive strength 126·5-176·0 Impact strength 0·17-1·2 Moulding temperature 140-220 Thermal expansion $1\text{-}5 \times 10^{-5}$ Dielectric strength 7·10-12·60 Inflammability Very slow burning to self-extinguishing Hard, rigid material, good electrical properties, resistance to heat, water and most organic solvents	Electrical applications Components where fast moulding cycles are desired Coatings Finishes for metals	Amberlac Aroplaz Aquaplex Bakelite Beetlealkyd (resins) Epok Erinite Plaskon Soalkyd Synolac Synresates (resins)
2	Epoxy resins (epoxide)	Solid Viscous Liquid Powder	Golden brown in natural form, but may be dyed or pigmented Specific gravity 1·15-2·1 Water absorption 0·07-0·15 Tensile strength 14-420 Compressive strength 84·5-210 Impact strength 0·34-13·5 Thermal expansion $1\text{-}10 \times 10^{-5}$ Moulding temperature 20-200 Dielectric strength 7·90-19·70 Inflammability Slow burning to self-extinguishing Good chemical resistance and exceptional adhesion to metals	Insulations Coatings Rectifiers Transformers Jigs and fixtures Patterns Printed circuits Reinforced plastic mouldings Electronic components Adhesives for glass, metal and wood	Araldite Bakelite epoxide D.E.R. Epikote Epotug Epon Lekutherin Maraglas Maraset Maree Petrox
3	Melamine formaldehyde (melamine)	Powder Resins	Translucent and opaque colours Specific gravity 1·4-1·95 Water absorption 0·08-0·60 Tensile strength 28·1-77·3 Compressive strength 175·8-281·0 Impact strength 0·17-0·4 Moulding temperature 120-160 Thermal expansion $2{\cdot}0\text{-}4{\cdot}5 \times 10^{-5}$ Dielectric strength 2·40-9·90 Inflammability Nonflammable Good electrical properties, high resistance to heat, hot water and chemicals; high surface gloss	Laminates Adhesives Lacquers Electrical instruments, parts and housing	Cymel Isomine Keramin Lamelite Meform Melbrite Melerex Melmac Melmex Melolam Melopas Mepal Melurac Melurit Resloom Ultrapas

(*Continued*)

APPENDIX B — *Contd*

(*Clauses* 9.3, 10.2 *and* 13.1)

THERMOSETTING MATERIALS

Sl No. (1)	Material (2)	Forms Available (3)	Physical Characteristics (4)	Possible Applications (5)	Common Trade Names (6)
4	Phenolic (phenol formaldehyde)	Rod Tube Powder Foam Resins	Available in black, brown, maroon, green, blue and other natural colours in darker shades. Cast resins, all colours Specific gravity 1·32-1·42 Water absorption 0·01-1·30 Tensile strength 42·2-63·3 Compressive strength 175·8-281·2 Impact strength 0·17-0·3 Thermal expansion 2·5-7·5 × 10^{-5} Moulding temperature 140-170 Dielectric strength 2·0-9·9 Refractive index 1·5-1·7 Inflammability Very slow burning Durability; resistance to heat, water, solvents and chemicals; electrical properties; ease of moulding and machining; clearness; brittle in thin section; dimensional stability	Cabinets Electrical fittings Knobs Handles Cameras Insulations Packaging Wood bonding Adhesives Covers for electrical instruments	Bakelite Catalin (cast resins) Catamould Catanam Cataplas Cataset Cegeite Cellobond Durez-phenol Elo Epok Fluocite Kauresin Kerit Mouldrite-phenol (resins) Nestor Nestrorite Phenite Phenorez Phenorin Philite Plenco Resinox Rockite Sternite Synmold Trolitan
5	Polyester	Film Foam Fibre Resin	Varies from clear to medium brown or yellow colour in natural form. It may also be dyed or pigmented Specific gravity 1·06-2·9 Water absorption 0·07-0·5 Tensile strength 21-492 Compressive strength 105·5-211·0 Impact strength 0·27-1·35 Thermal expansion 1·5-4·0 × 10^{-5} Moulding temperature 10-160°C Dielectric strength 3·90-17·70 Inflammability Very slow burning Good heat resistance, films are transparent and flexible having good electrical properties	Surface coating Adhesives Packaging Antenna masts Reinforced plastics Corrosion resistance tanks, pipes, etc Electrical appliances Plotting of electronic circuits	Bakelite Beetle Crystic Estal Filabond Gebraster Glidpol Hetron Hostaphane Isokote Keripol Laminae Marco Melinex Mylar Norsodyn Oacron

					Palatal Pleogen Polymaster Rhodester Soredup Sterpon Straytyl Stypol Synolite Terphane Terylene Vestopal Vibrin
6	Urea formaldehyde (urea)	Powder Resin	Transparent and opaque colours Specific gravity 1·4-1·6 Water absorption 0·4-0·8 Tensile strength 42·2-77·3 Compressive strength 175·8-246·0 Impact strength 0·34-0·47 Thermal expansion $2·5\text{-}3·0 \times 10^{-5}$ Moulding temperature 120-150 Dielectric strength 0·80-9·90 Refractive index 1·45-1·56 Inflammability Very slow burning to nonflammable Good light transmission and diffusion; good surface gloss; noteworthy arc resistance; odourless and tasteless; resistance to heat	Cabinets Knobs Laminates Lacquers Adhesives Wood bonding	Bakelite Beetle Catalure Cellobond Flowrite Isopal Kaurit Mouldrite Nestorite urea Plaskon Plaskon urea Pollopos Pressrite Resolite Rockite Scarab Sylplast Uforin Uformite

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